



Ongoing and Planned Research at NRMRL-Ada on Gas and Vapor Intrusion

Presentation for Vapor Intrusion Forum

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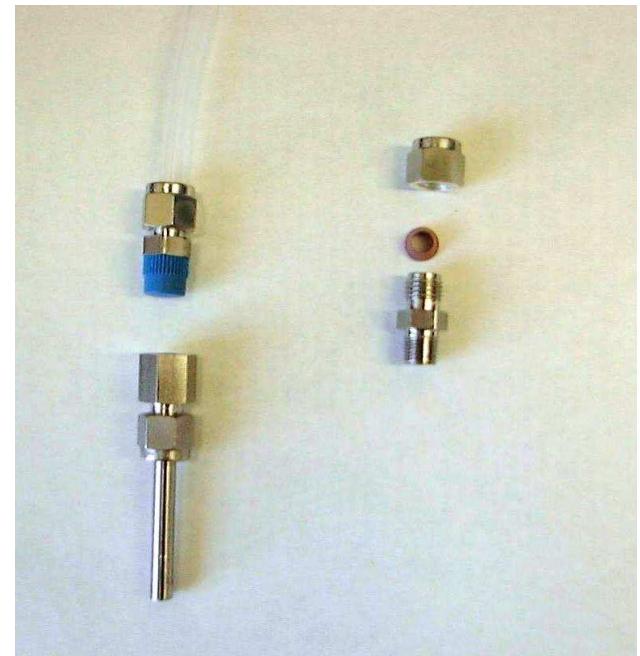
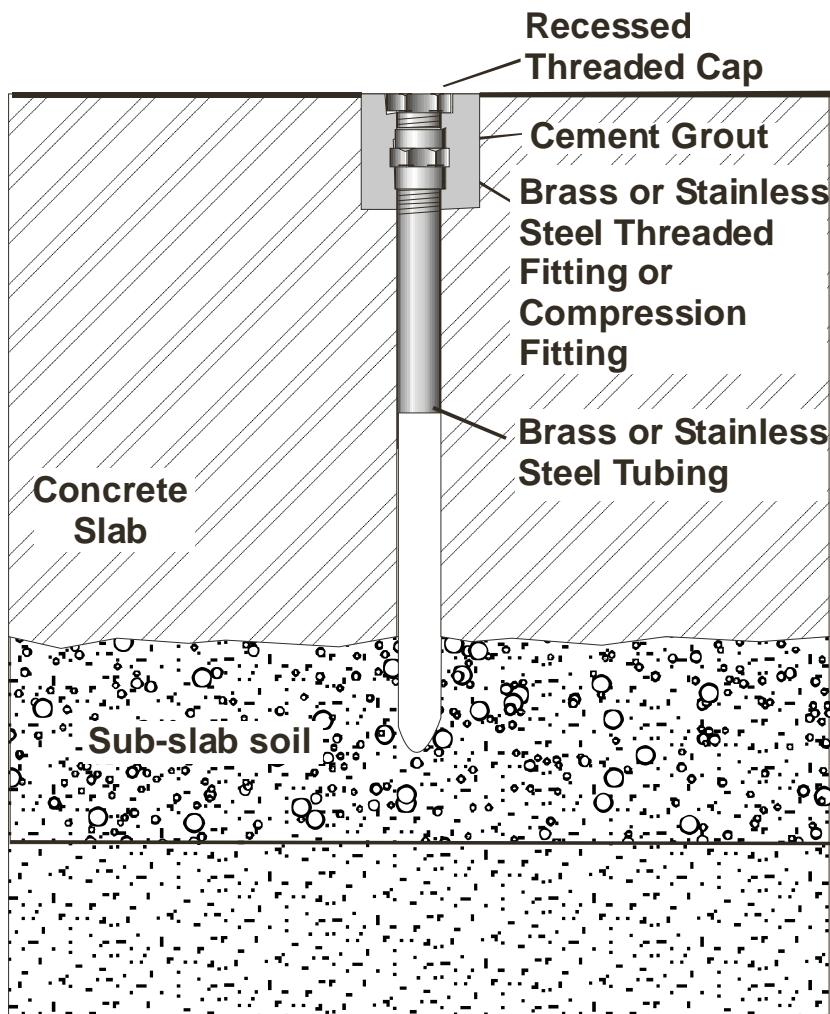
Office of Research and Development
National Risk Management Research Laboratory,
Ground Water and Ecosystem Restoration Division, Ada, OK



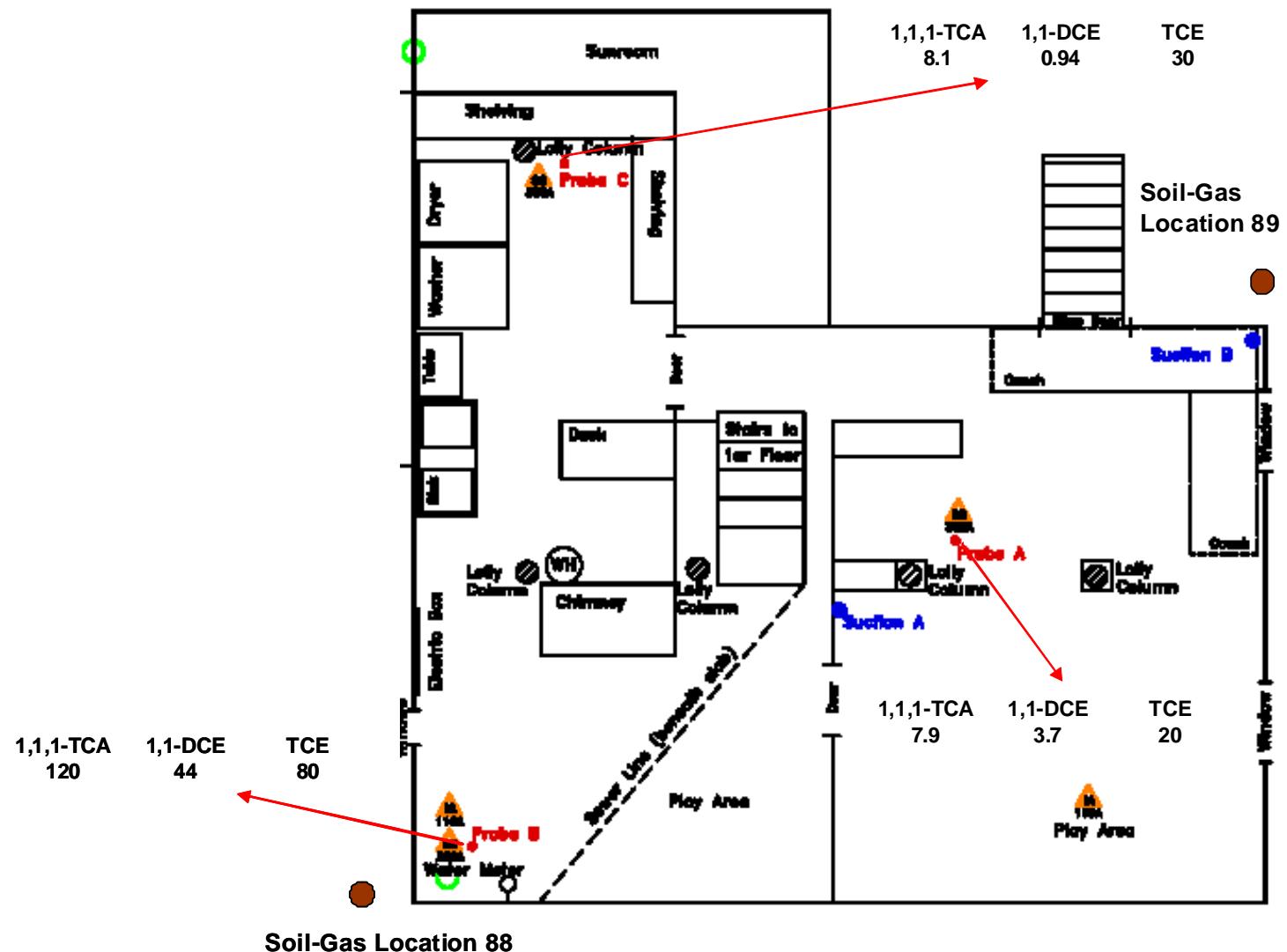
Ongoing Research at NRMRL-Ada on Gas and Vapor Intrusion

- Improvement of ground-water, soil-gas, and sub-slab sample techniques.
- Development of forensic techniques to differentiate vapors and gases in indoor air from background sources.

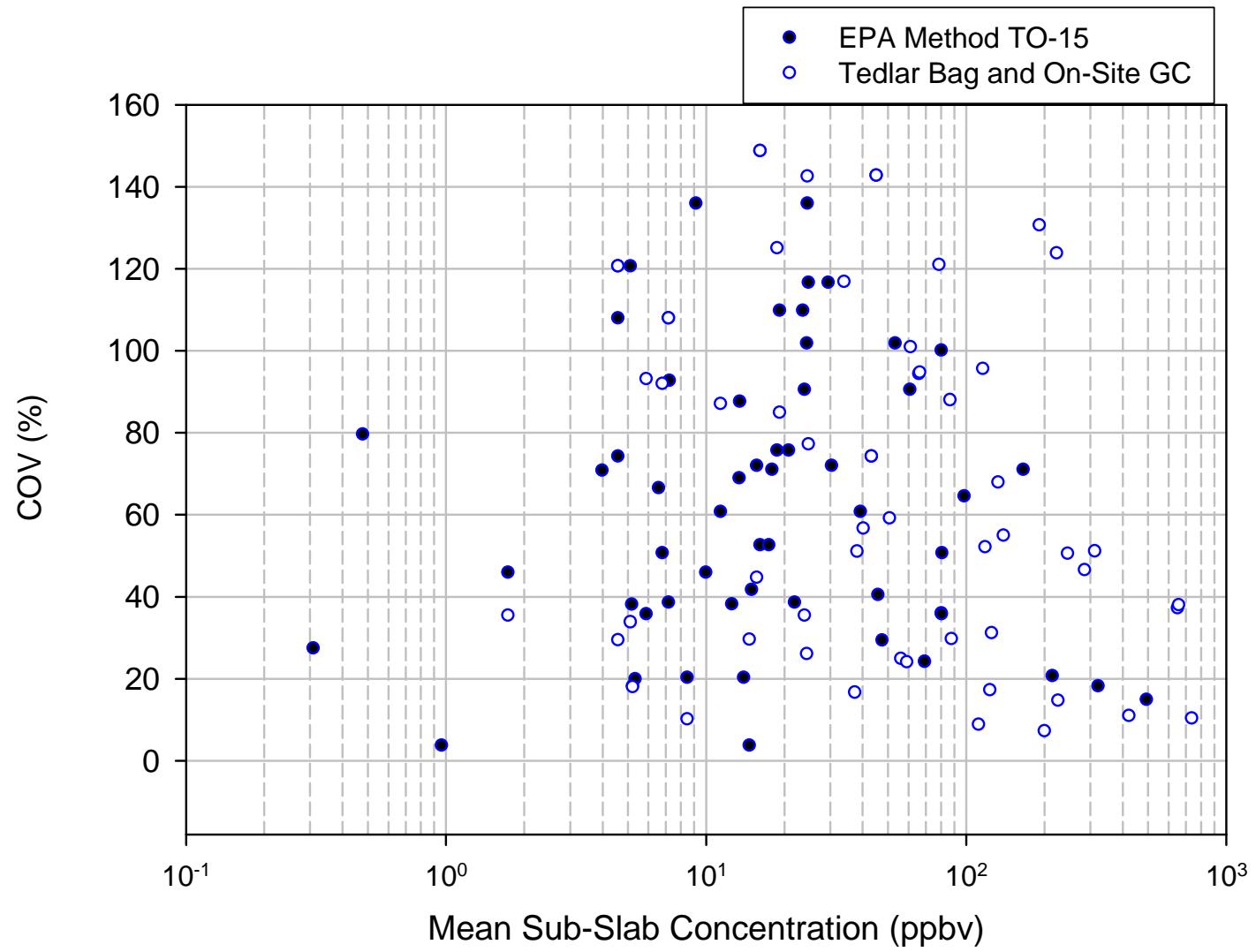
Design and Sampling of Sub-Slab Probes



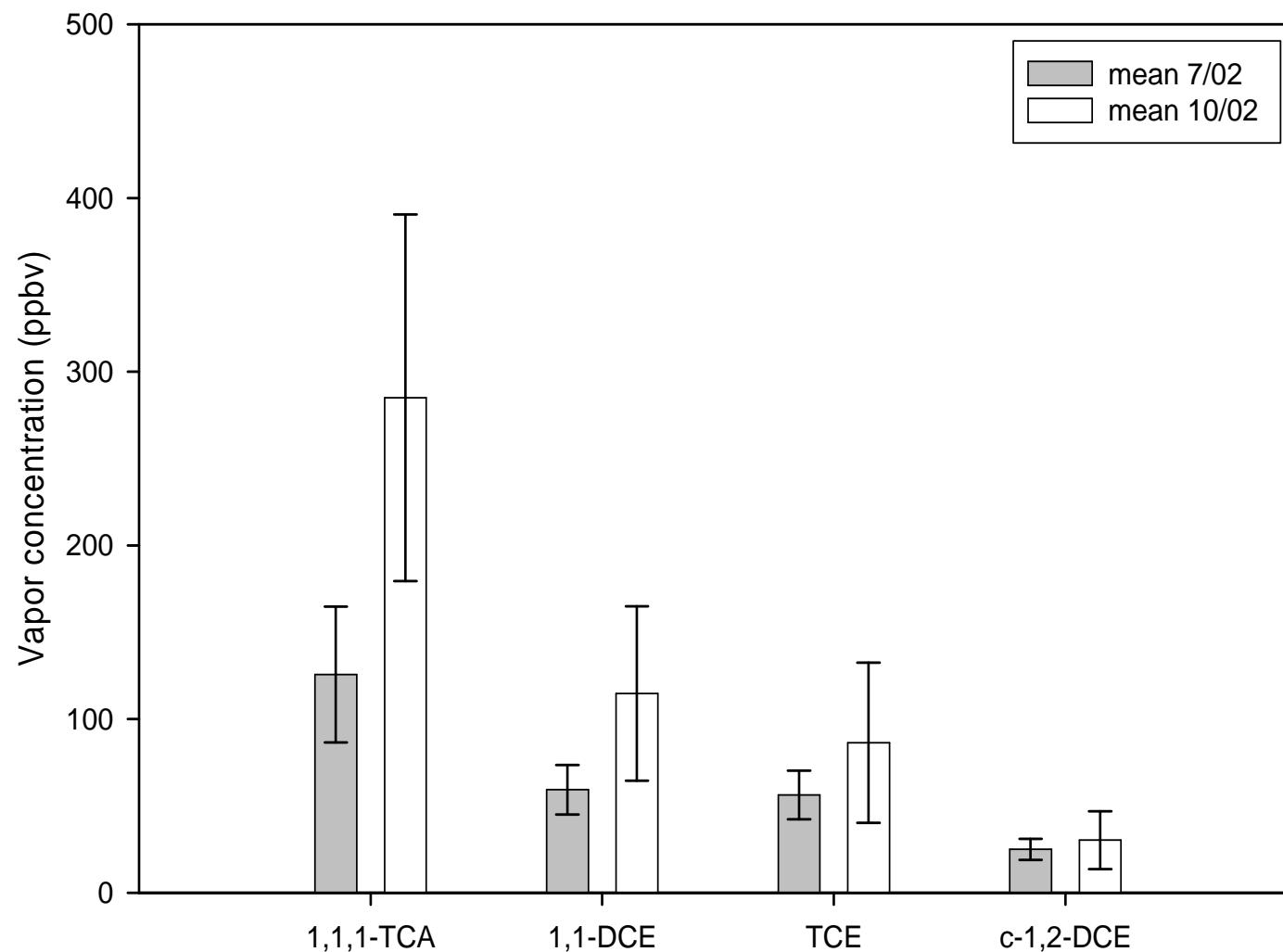
Probe Placement and Number



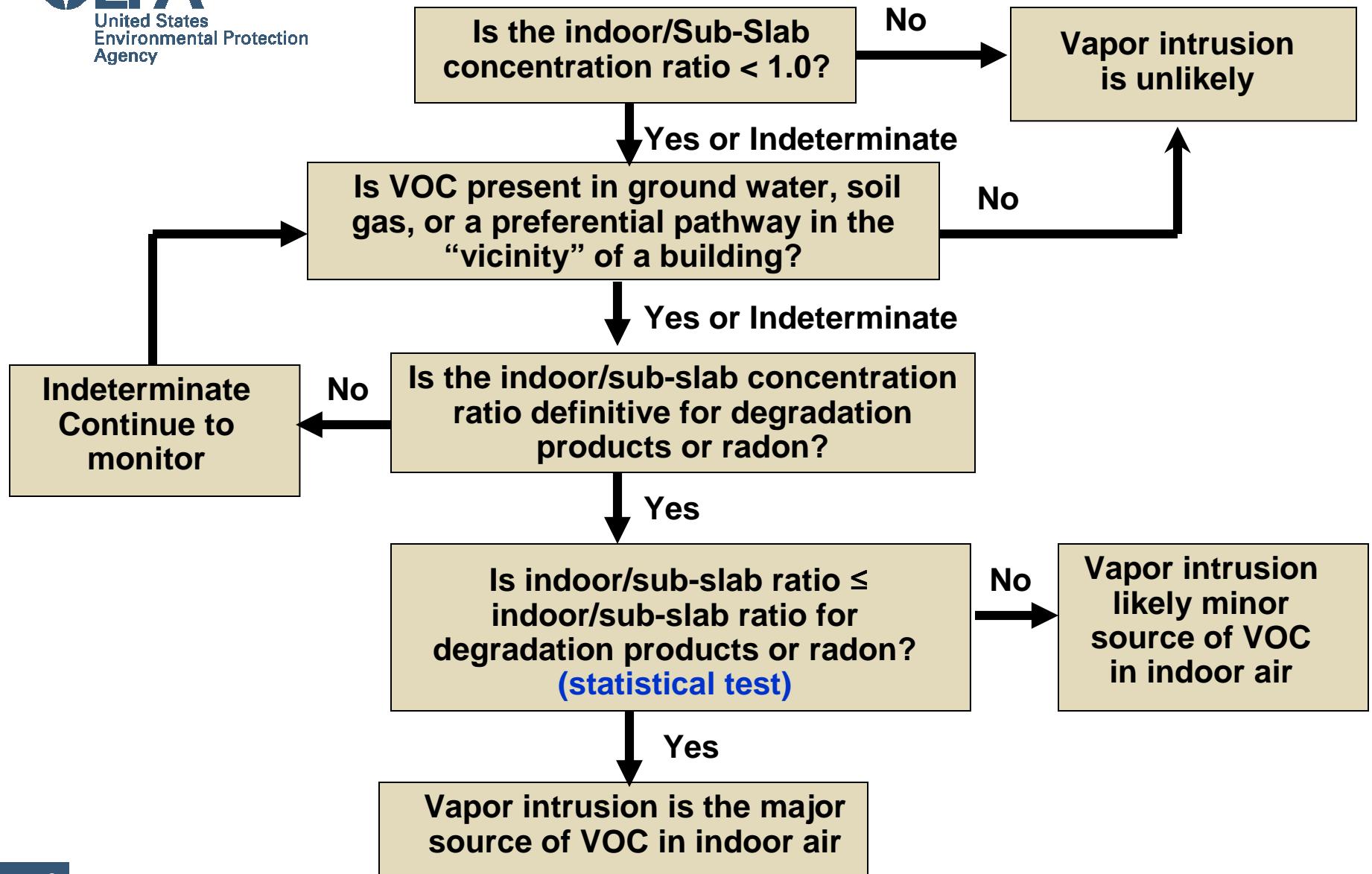
Spatial Variability (order of magnitude variability)



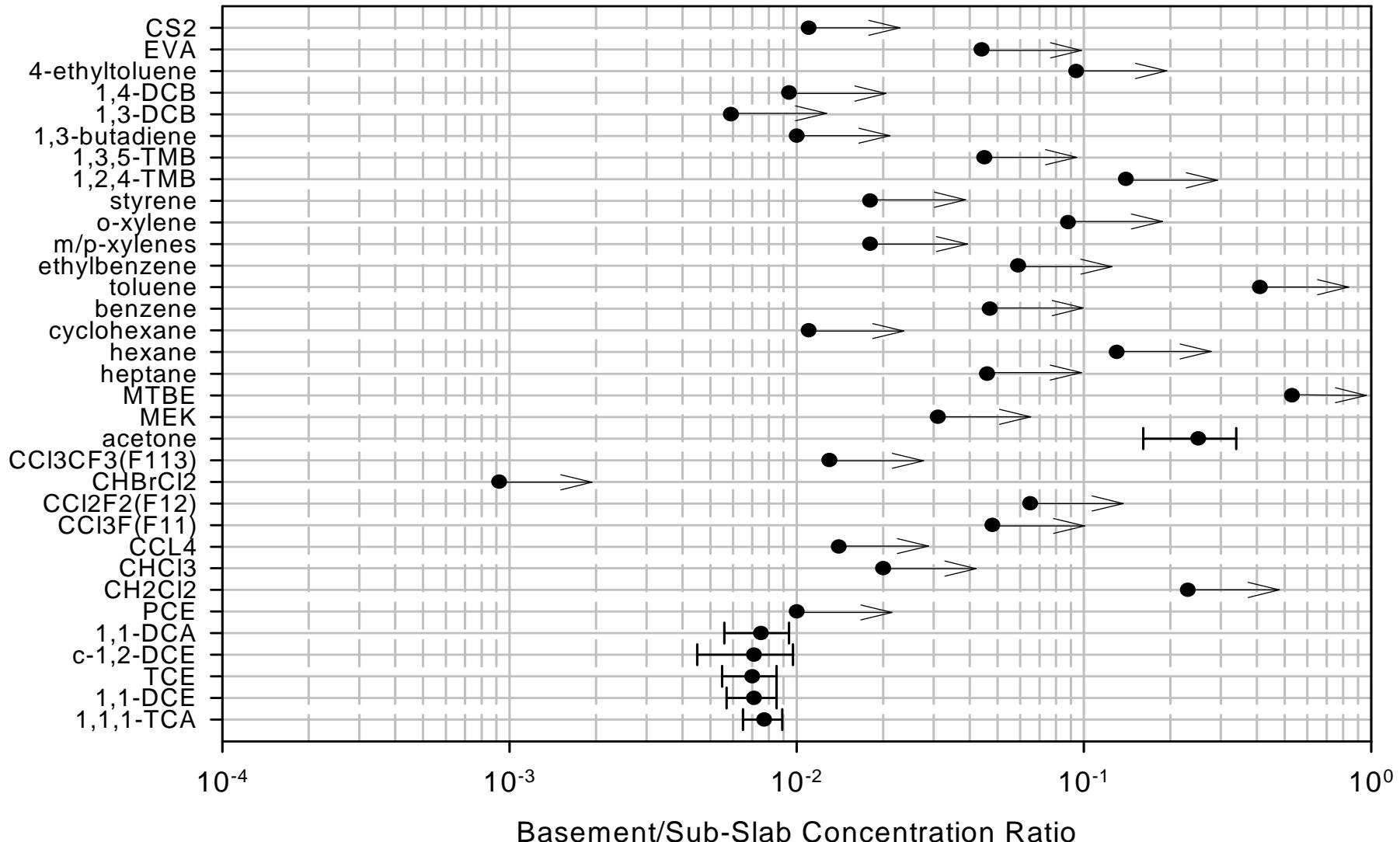
Temporal Variability (factor of two variability)



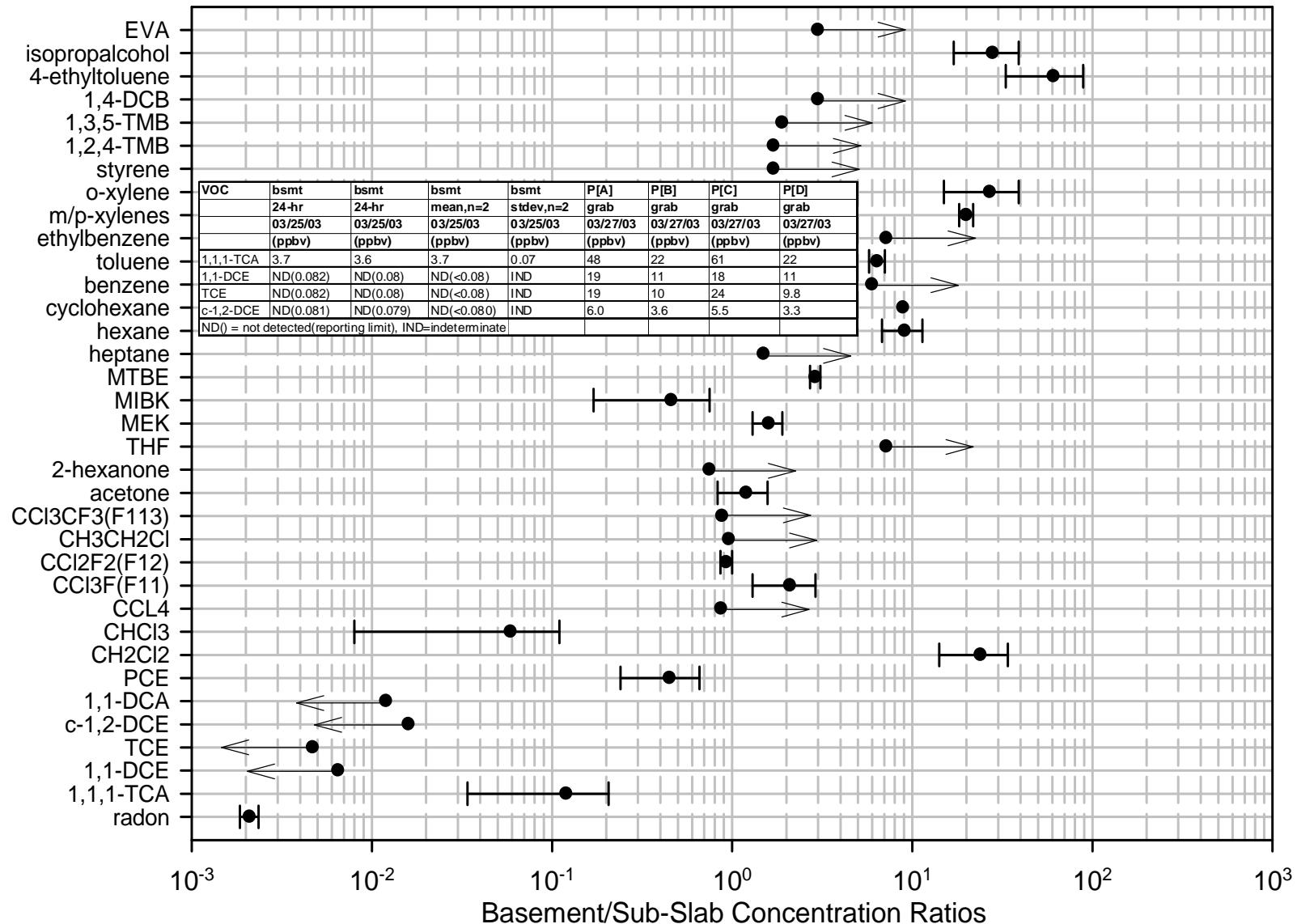
Algorithm to Detect Vapor Intrusion



Use of Degradation Products to Evaluate Vapor Intrusion - House C at the Raymark Site



Use of Radon to Evaluate Vapor Intrusion - House H at the Raymark Site

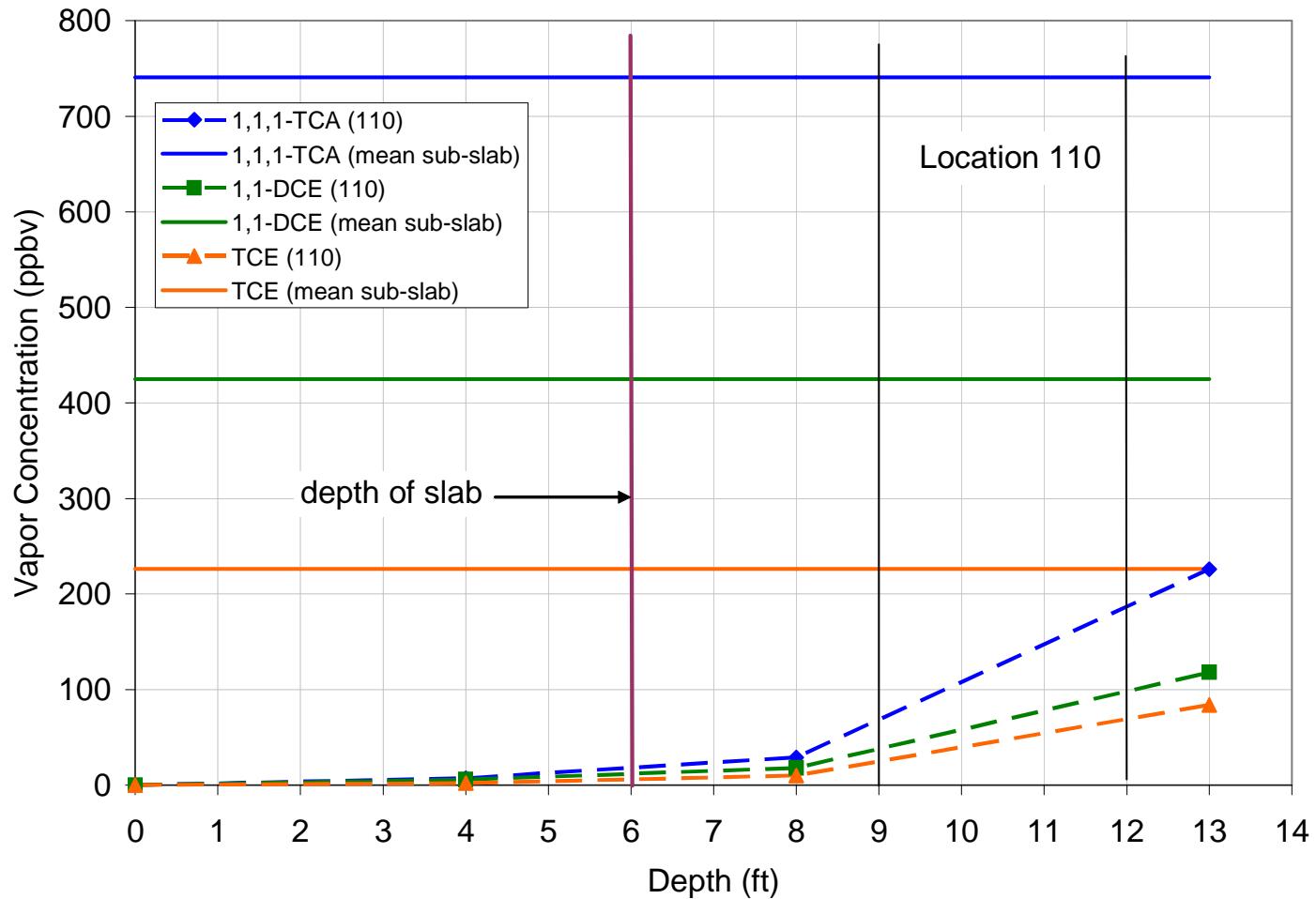


Assessment of Vapor Intrusion in Homes Near the Raymark Superfund Site Using Basement and Sub-Slab Air Samples

DiGiulio, D.C., C. Paul, R. Cody, R. Willey, S. Clifford, P. Kahn, R. Mosley, A. Lee, and K. Christensen. 2006. *Assessment of vapor intrusion in homes near the Raymark Superfund Site using basement and sub-slab air samples.* EPA/600/R-05/147, U.S. Environmental Protection Agency, Office of Research and Development, National Risk Management Research Laboratory.

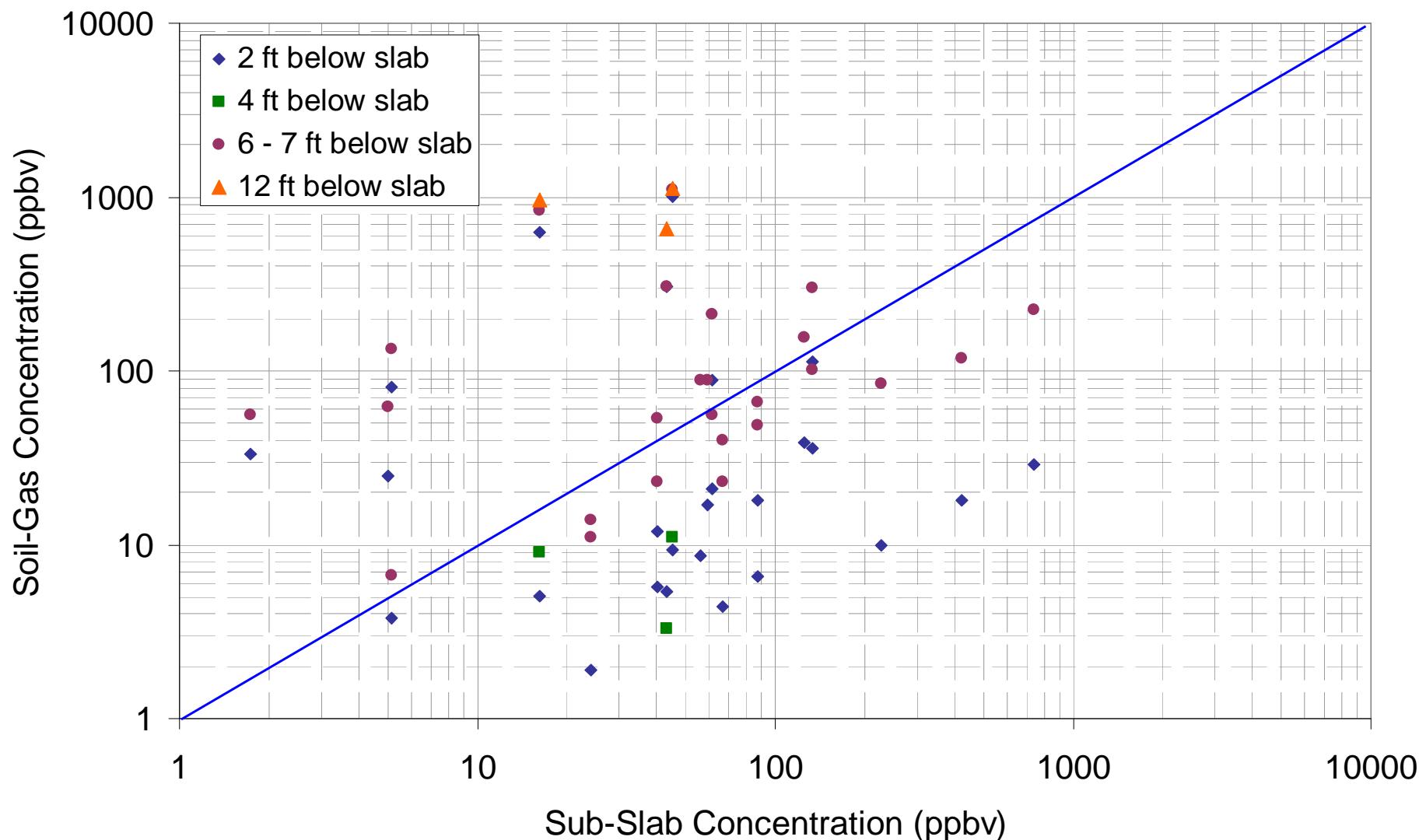


House C – Location 110



VOC	bsmt	scaled	P[A]	P[B]	P[C]	P[D]	sub-slab	sub-slab	sub-slab	bsmt/	bsmt/
	1-hr	stdev	grab	grab	grab	grab	mean,n=4	stdev,n=4	cov,n=4	sub-slab	sub-slab
	07/16/02	cov=6%	07/16/02	07/16/02	07/16/02	07/16/02	07/16/02	07/16/02	07/16/02	ratio	stdev
	(ppbv)	(ppbv)	(ppbv)	(ppbv)	(ppbv)	(ppbv)	(ppbv)	(ppbv)	(%)	(-)	(-)
1,1,1-TCA	3.8	0.23	833	650	757	722	741	76.1	10.3	5.1E-03	6.1E-04
1,1-DCE	2.3	0.14	486	374	423	416	425	46.2	10.9	5.4E-03	6.7E-04
TCE	1.5	0.09	260	201	249	195	226	33.0	14.6	6.6E-03	1.0E-03
c-1,2-DCE	0.57	0.03	120	98	61	74	88	26	30	6.5E-03	2.0E-03
								mean and standard deviation of basement/sub-slab ratio		5.9E-03	6.0E-04

Soil-Gas Versus Sub-Slab Samples





Soil-Gas Sampling with Geoprobe Unit





PRT Sample System

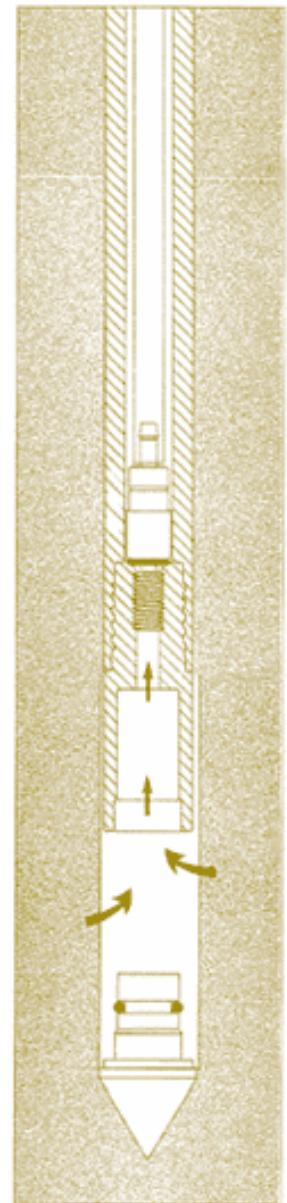


expendable point and holder

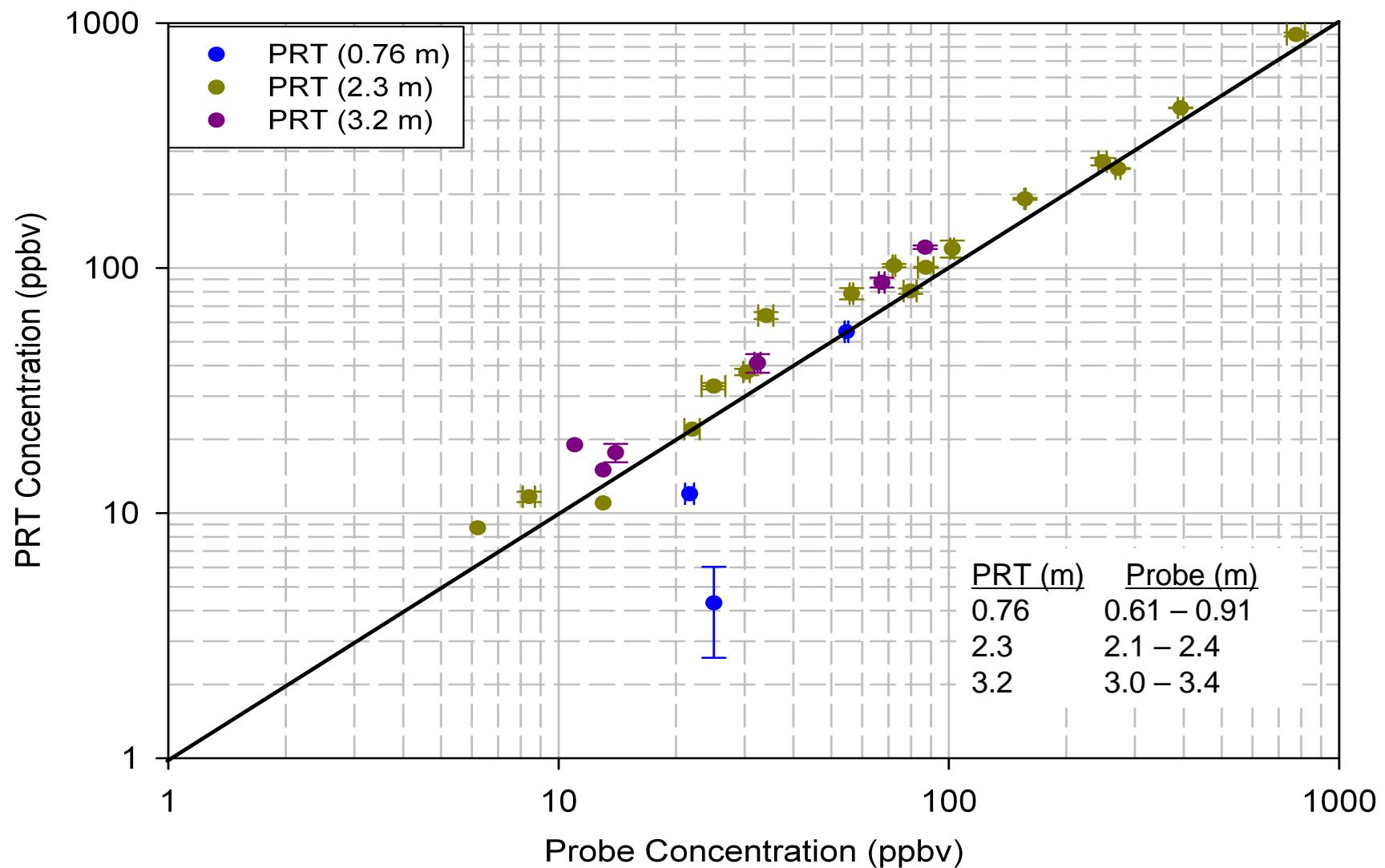
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PRT adapter with O-ring and 0.64 cm (1/4") ID Teflon tubing



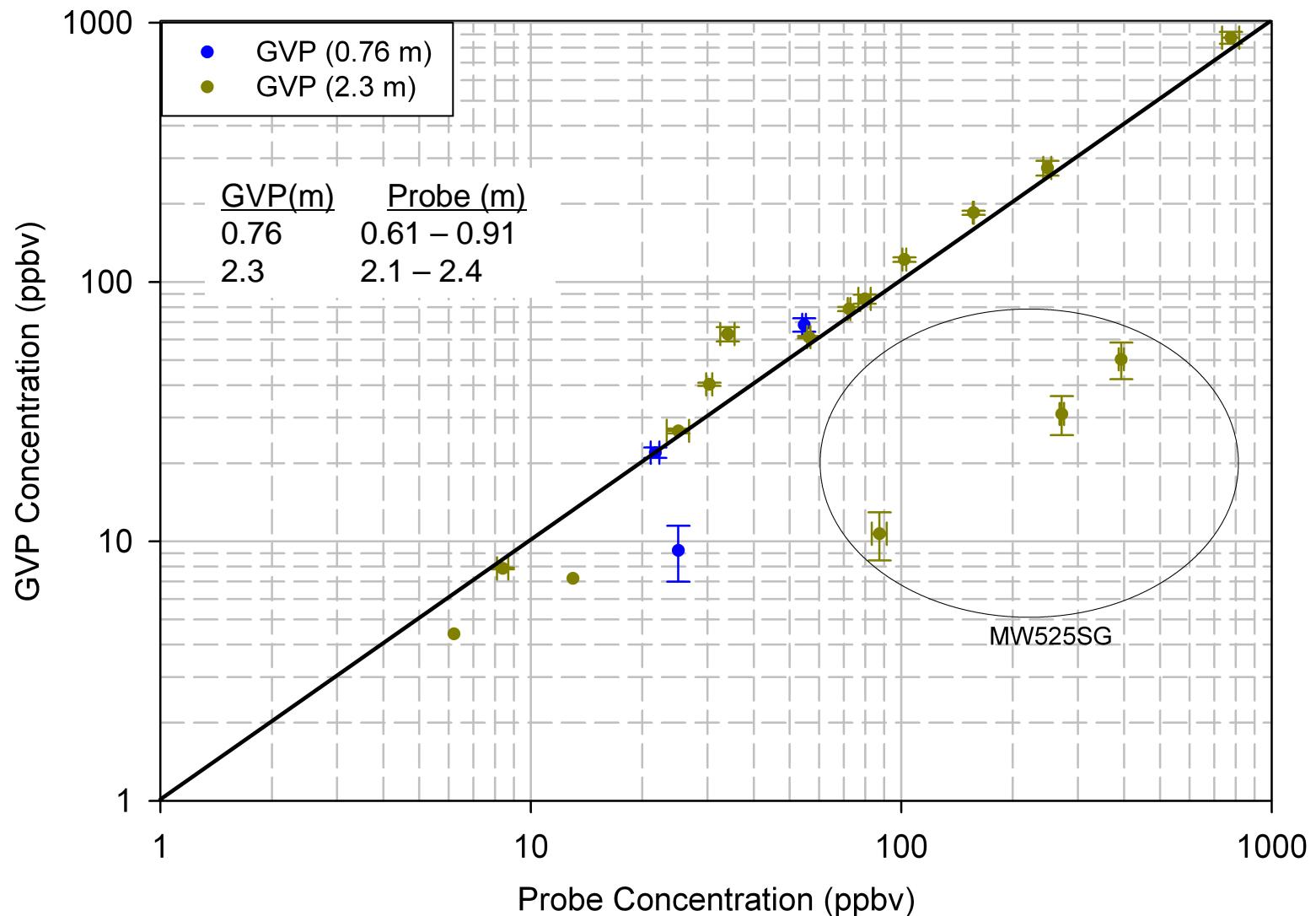
PRT versus Dedicated Probe



Use of Rotary Hammer Drill to Advance AMS Probe



GVP versus Dedicated Probe



DiGiulio, D.C., C. Paul, B. Scroggins, R. Cody, R. Willey, S. Clifford, R. Mosley, A. Lee, K. Christensen, and R. Costa. 2006. *Comparison of Geoprobe PRT, AMS GVP soil-gas sampling systems with dedicated vapor probes in sandy soils at the Raymark Superfund Site*. EPA/600/R-06/11, U.S. Environmental Protection Agency, Office of Research and Development, National Risk Management Research Laboratory.

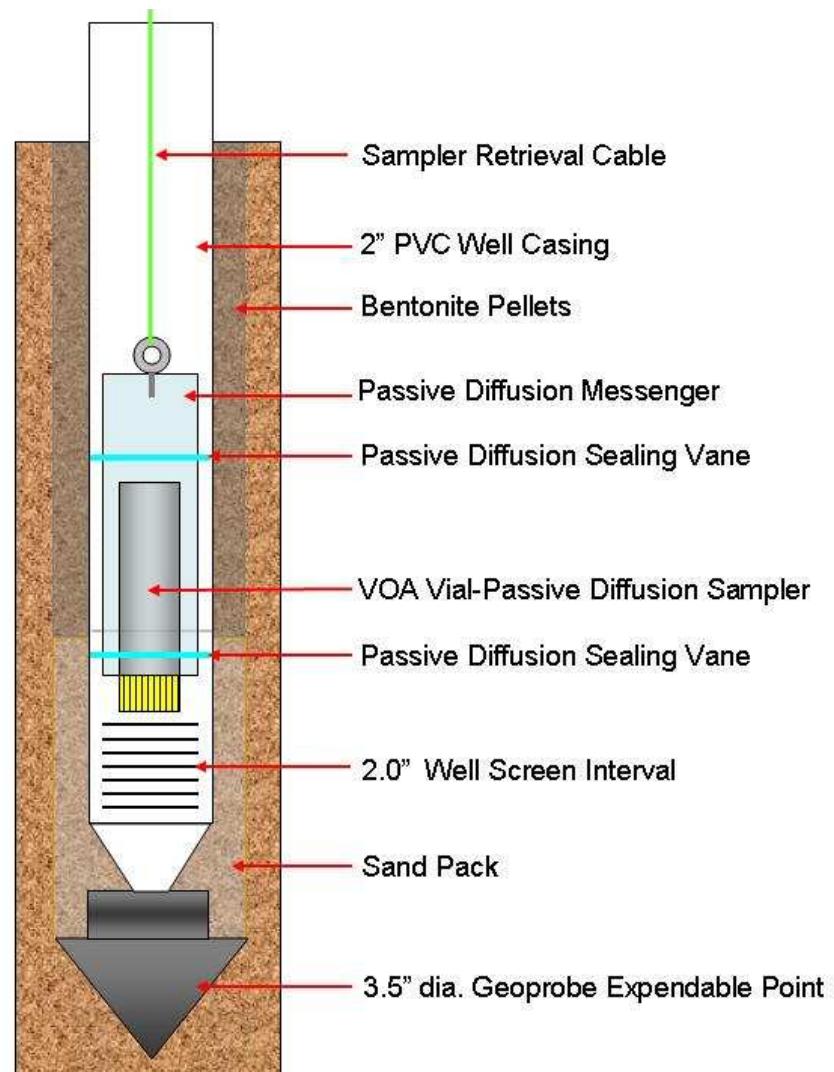
Comparison of Geoprobe® PRT and AMS GVP Soil-Gas Sampling Systems with Dedicated Vapor Probes in Sandy Soils at the Raymark Superfund Site



<http://www.epa.gov/ada/topics/vapor.html>



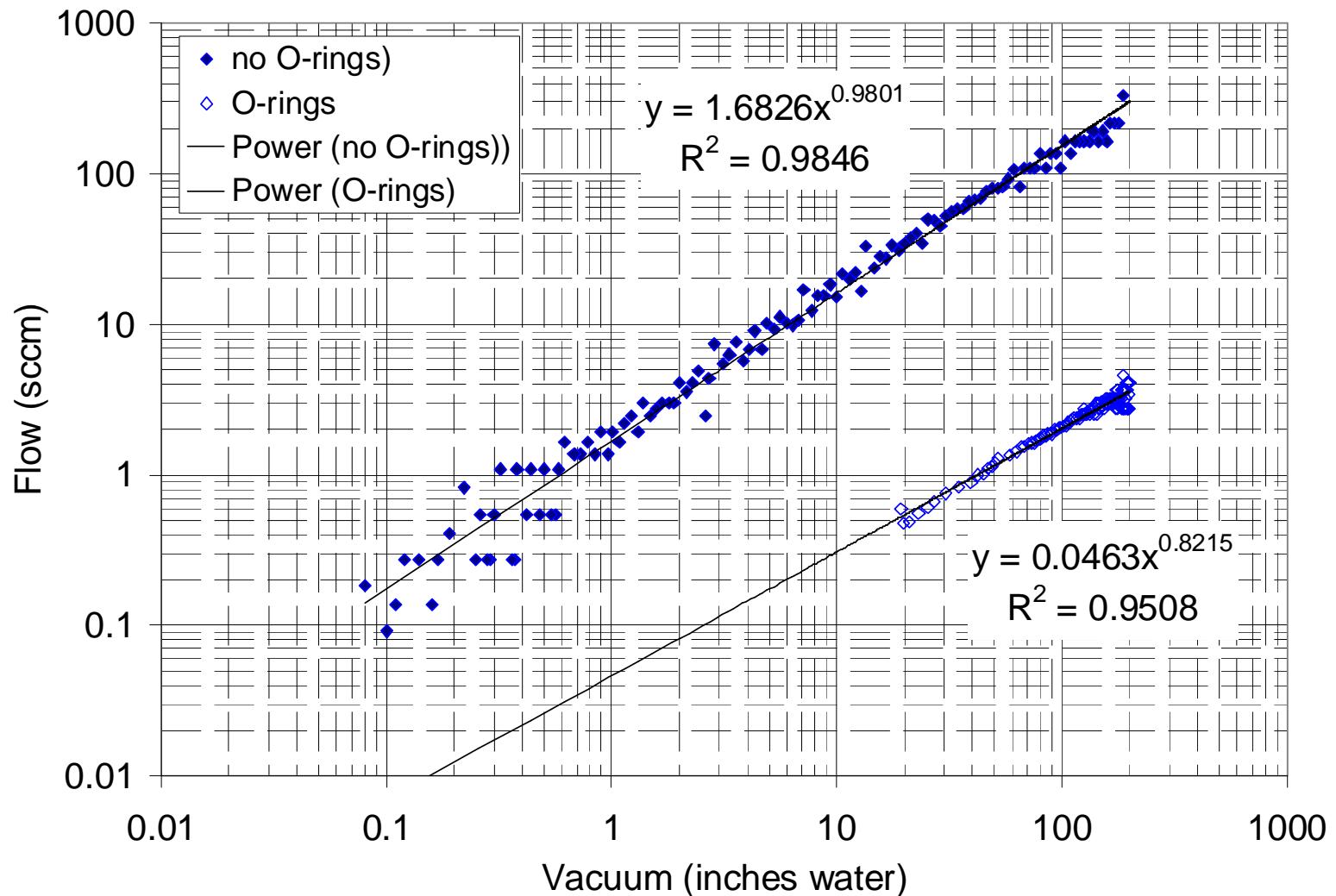
Passive Diffusive Sampler With Polyethylene Tubing to Ex-Cap – Testing at Hal's Chevron in Green River, UT



Checking the Integrity of Ex-Caps



Leakage Through Ex-Caps *(Calculated using Ideal Gas Law)*



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Depending on vacuum in pipe (permeability of soil), leakage through Ex-Cap varied from 0.3% to 100%

Heuristic Analysis of Leakage in Wellbore

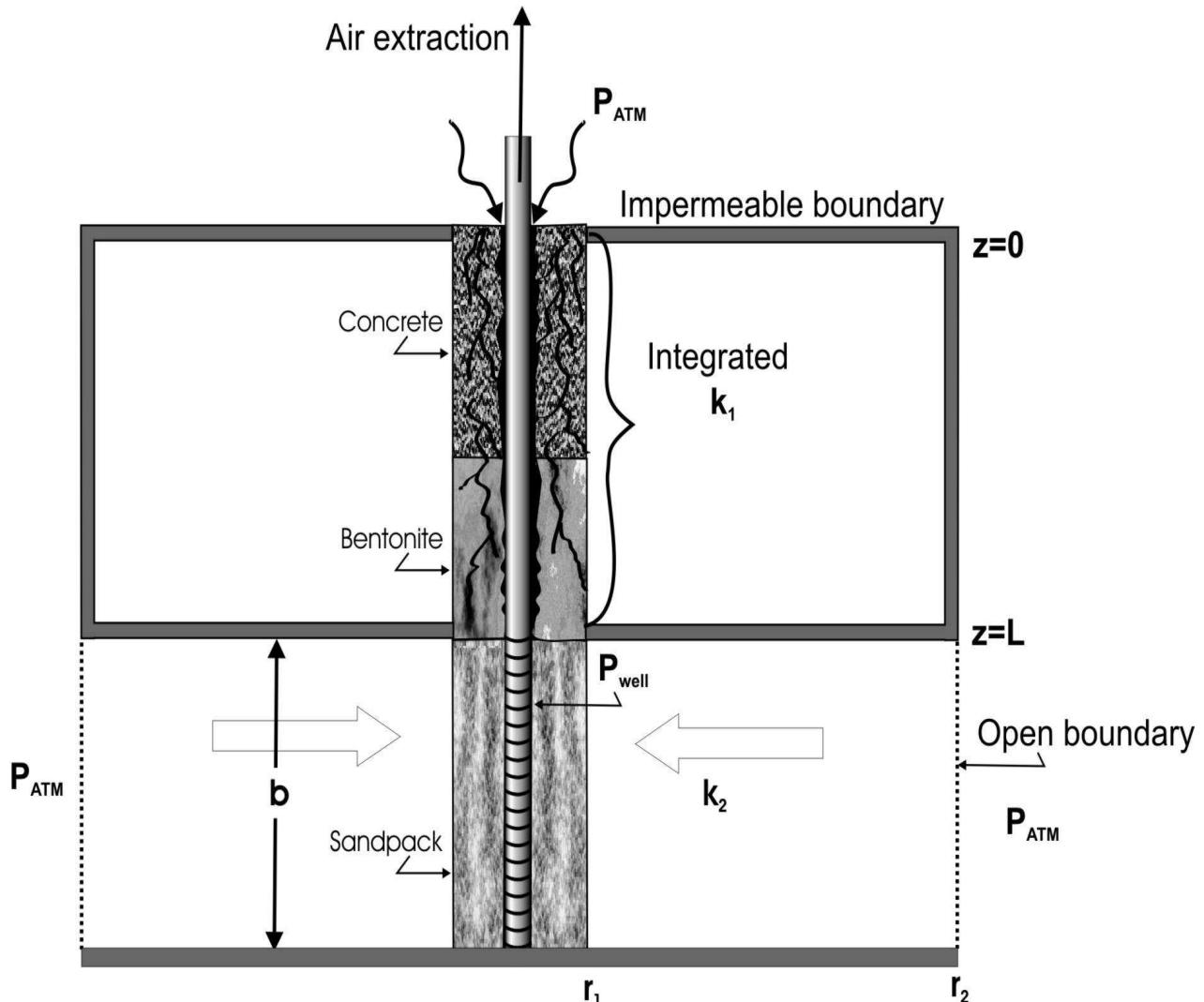
$$Q_z = \pi r_w^2 \frac{k_1}{2\mu P_w} \left(\frac{\phi_{atm} - \phi_w}{L} \right)$$

$$Q_r = \frac{\pi b k_2}{\mu P_w} \frac{(\phi_{atm} - \phi_w)}{\ln(r_{atm}/r_w)}$$

$$\xi = \frac{Q_z}{Q_z + Q_r}$$

$$\xi = \frac{1}{1 + C(k_2/k_1)}$$

$$C = \frac{2bL}{r_w^2 \ln(r_{atm}/r_w)}$$

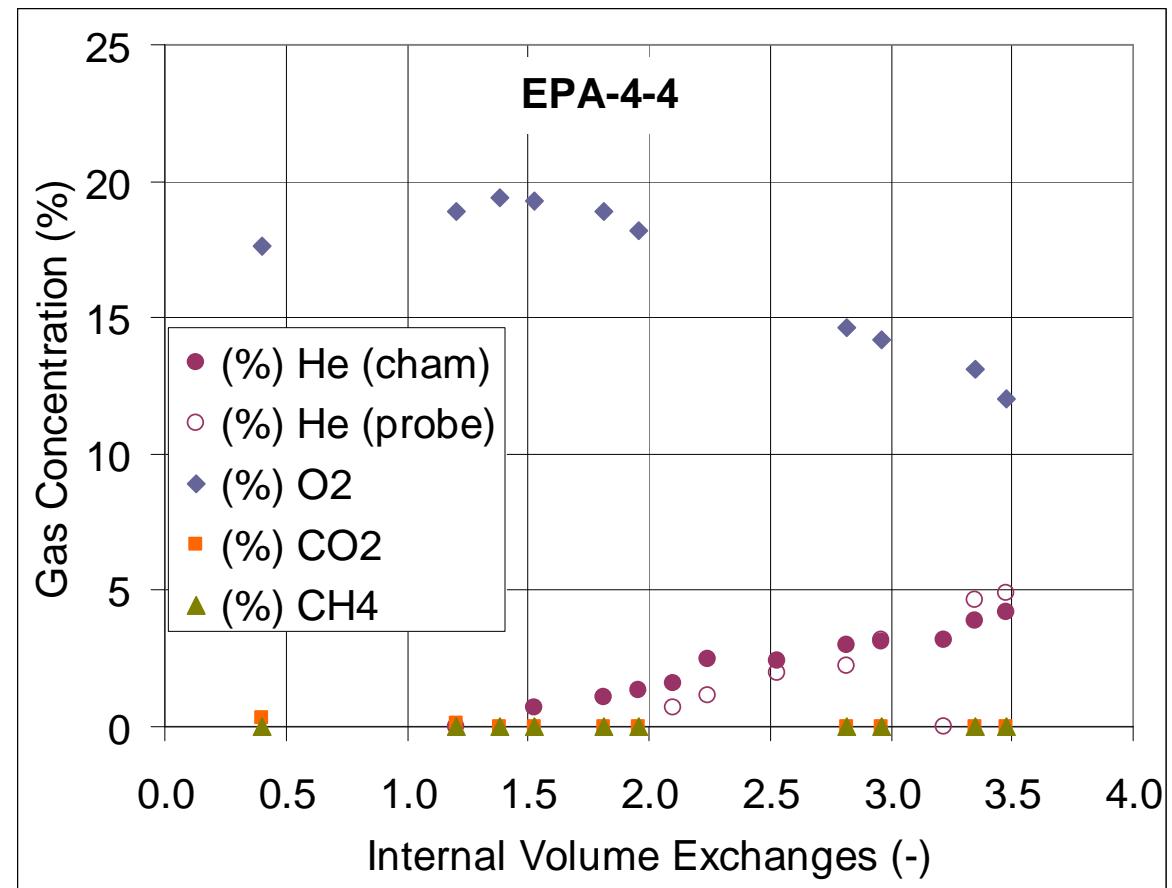
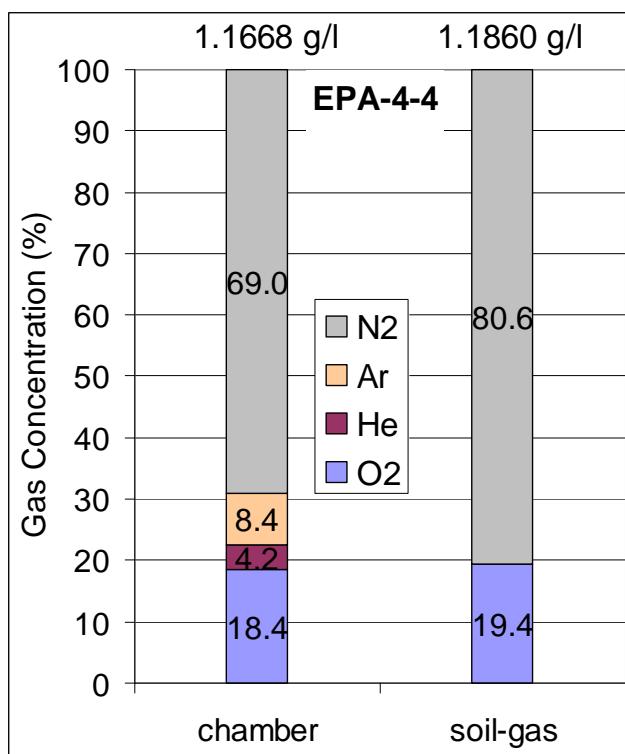


- Leakage is a function of the permeability contrast between the borehole and surrounding media and geometric factors.
- The potential for leakage increases with decreasing formation permeability.

Leak Testing



Leak Test at EPA-4-4 Using He



Purge Testing Working Conceptual Model

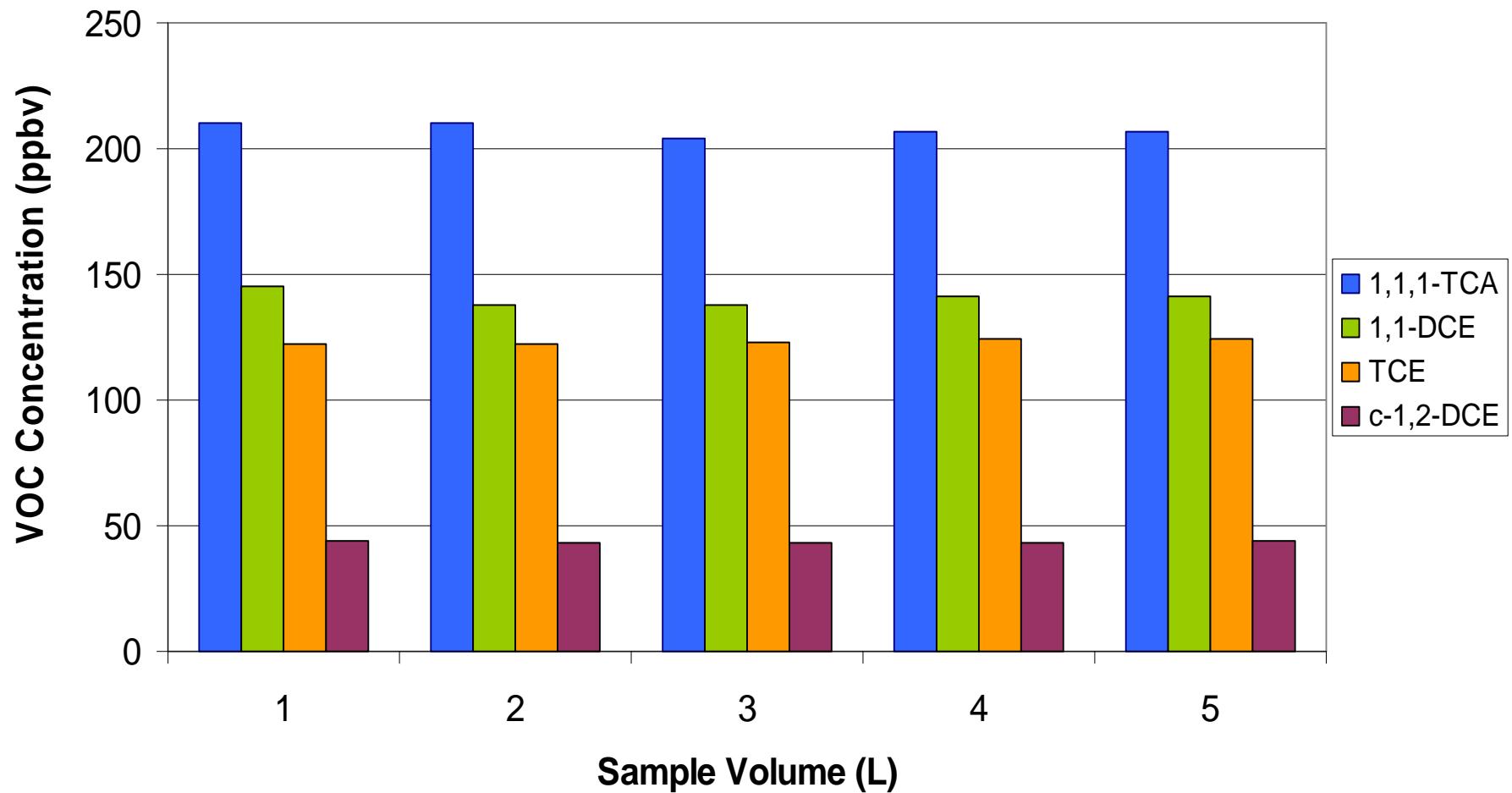
In the absence of leakage:

If vapor equilibrium exists, few (1 - 3) purge volumes will be required to stabilize concentration.

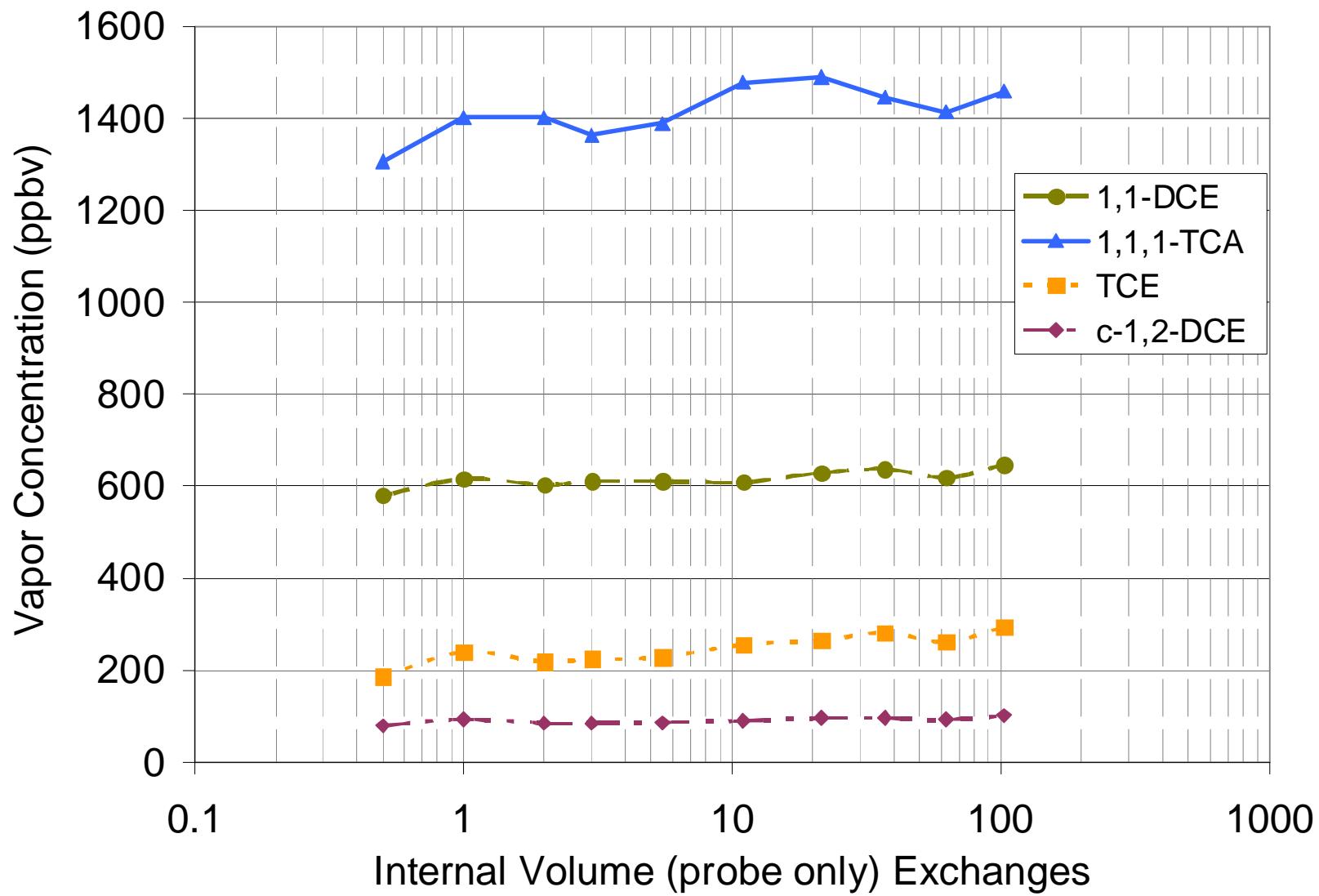
If vapor equilibrium does not exist, several (> 3) purge volumes will be required to stabilize concentration.

If excessive gas extraction occurs, concentration will slowly decrease from atmospheric recharge or concentration will slowly increase as the volume of impacted soil increases.

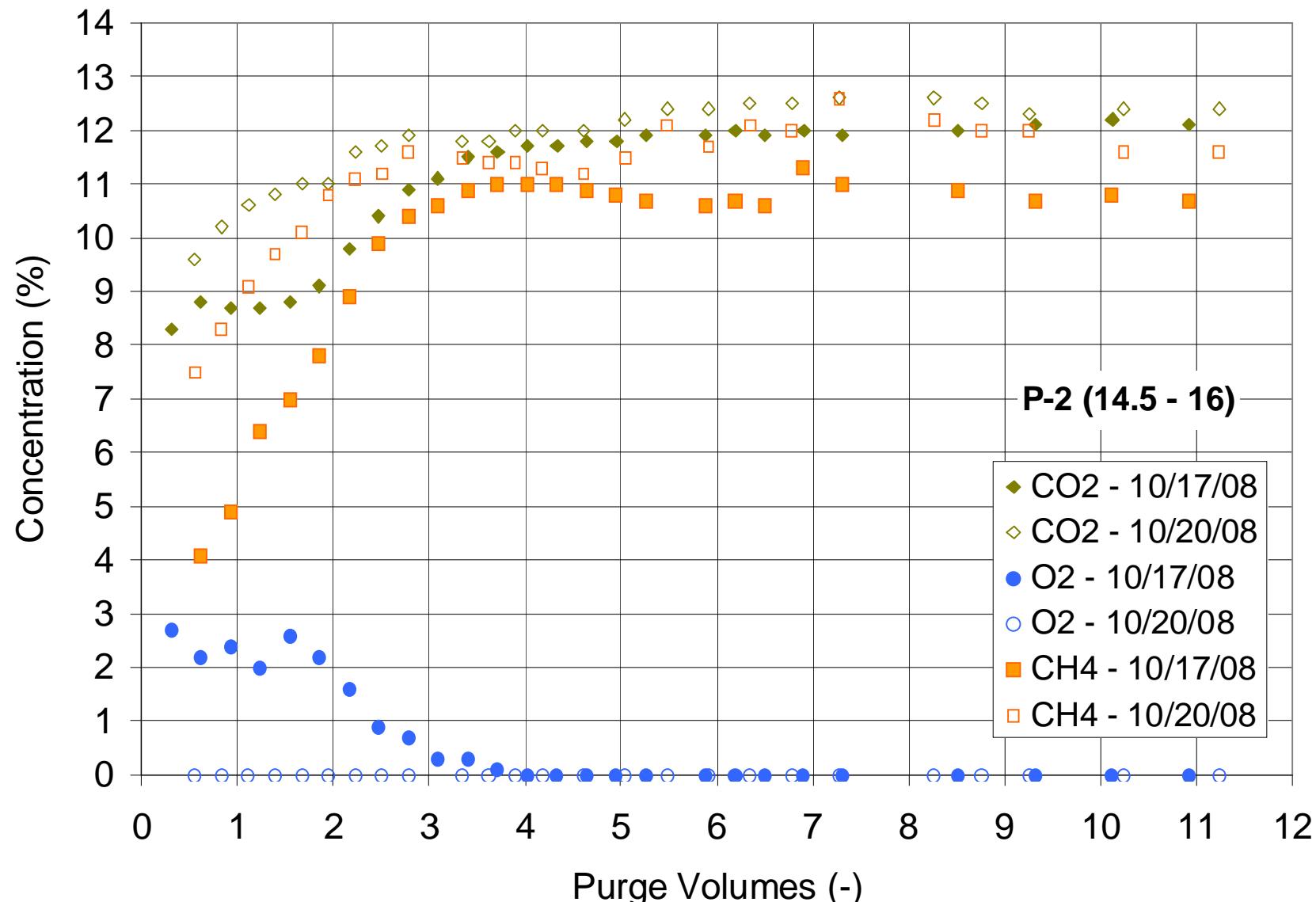
VOC Concentration as a Function of Sample Volume in Sub-Slab Probe



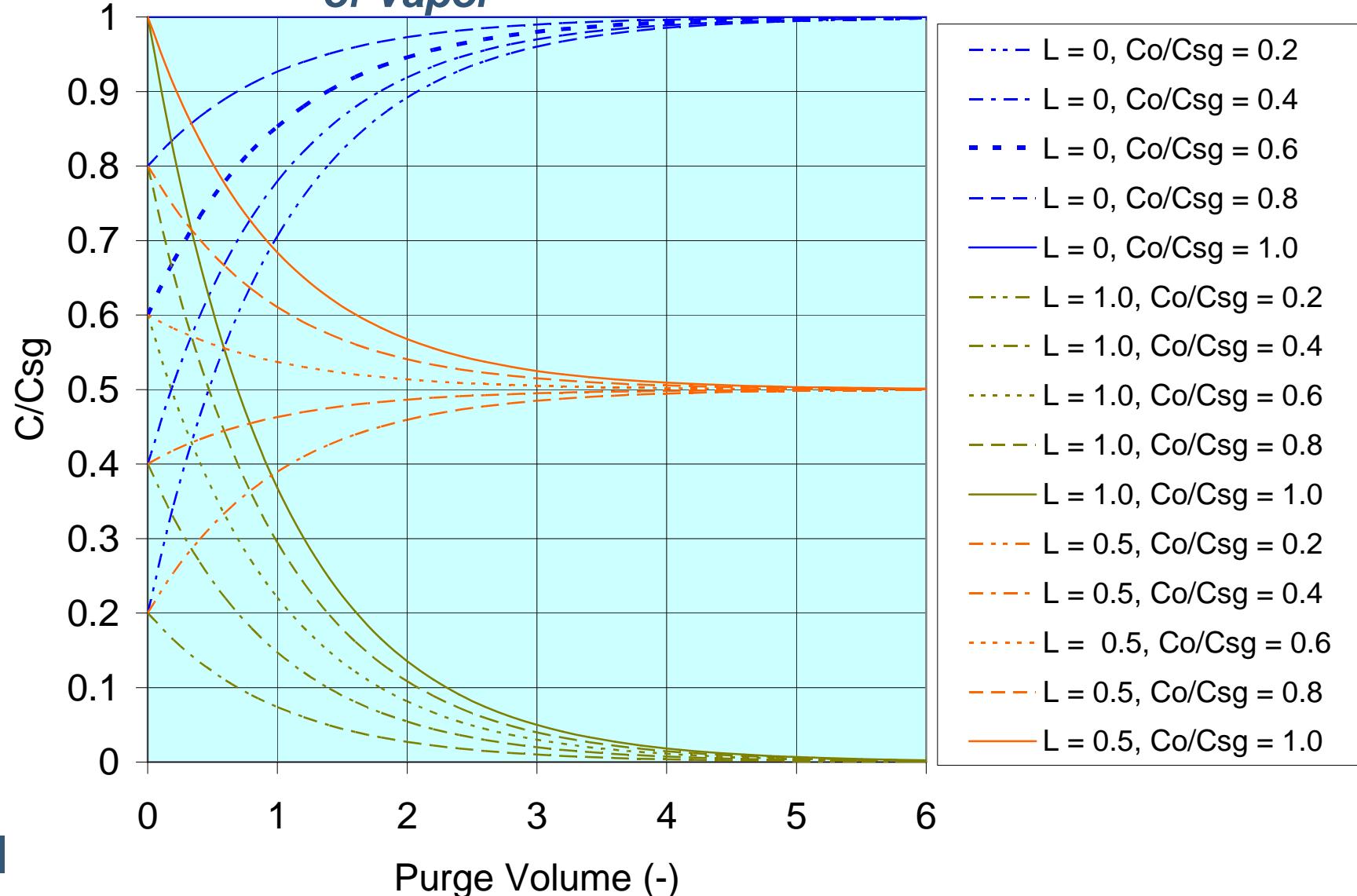
VOC Concentration as a Function of Internal Volume in Vapor Probe



Purge Testing at Oil Center, Oklahoma



Sample Concentration as a Function of Leakage, Initial Probe Concentration, and Soil-Gas Concentration When Atmosphere is not a source of Vapor





Questions?